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Note by Suzanne Souffrin
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ON THE THERMAL EQUILIBRIUM OF ELECTRONS IN THE CHROMOSPHERE

(Sur l'equilibre thermique des electrons dans la chromosphere)

(FRANCE)

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Note by Suzanne Souffrin
Presented by M.Andre Danjon

ABSTRACT

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The author seeks the determination of temperature difference between electrons and ions in the chromosphere, using the energy balance sheet and simplifying hypotheses on radiation and particles. It is found that it is negligible.

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COVER-TO-COVER TRANSLATION

In the chromosphere the electrons receive their energy from ions and atoms on one part, and from radiation on the other. Besides, it is well known that the latter is not in equilibrium with the particles. One must thus verify that their kinetic temperature is equal to that of atoms and ions, as this is customarily admitted.

For a qualitative study it is sufficient to consider the following model: A hydrogen atmosphere, the atoms of which are redu-

ced to two levels and one continuum (L_α and the Lyman continuum), and which is subject to a radiation field such that

a. for transitions bound levels $\rightleftharpoons$ continuum, the intensity distribution es represented by a Planck function at 5000 temperature and a dilution factor of 1/2;

b. the microreversibility of radiative transitions $1 \rightleftharpoons 2$ is assured.

These two hypotheses were admitted to avoid having to resolve simultaneously the statistical equilibrium equations and the transfer equation. Finally radiation by brehmstrahlung has been neglected.

Let us write that the variation of the mean electronic energy per unit of time is zero :

$$D\left(\frac{3}{2}kT_e\right) = 0 \qquad (1)$$

and let us make explicit the D_i contributions of various processes.

1. Elastic Collisions. Let us note that the electrons-electrons collisions do not intervene in the energy equation.

a. Electrons-Atoms Collisions. — Admitting that the interaction potential between electrons and atoms is an induced dipole potential, and utilizing the natural values of the collision operator computed by J. Naze [1], the contribution to D may be written in the form

$$D_{1a}\left(\frac{3kT_e}{2}\right) = 1{,}55.10^{-26} N_a(T_a - T_e), \qquad (2)$$

N_a, T_a and N_e, T_e, are the numerical densities and temperatures of atoms and electrons respectively.

b. Collisions Electrons-Ions. — The interaction potential being Coulomb, the corresponding contribution according to Spitzer [2] is :

$$D_{1b}\left(\frac{3kT_e}{2}\right) = 0{,}87.10^{-17} N_e (T_a - T_e) T_e^{-\frac{3}{2}}. \qquad (2')$$

2. Ionizations and Recombinations by Collisions. — Taking as the efficient section that calculated classically, the variation of the mean electronic energy is written

$$D_2\left(\frac{3KT_e}{2}\right) = -\frac{7{,}34.10^{-16}}{T_e^{\frac{1}{2}}} \sum_{n=1,2} N_n \left(1 - \frac{1}{b_n}\right) \times \left[\exp\left(-\frac{\chi_1}{n^2 kT_e}\right) - E_1\left(-\frac{\chi_1}{n^2 kT_e}\right)\frac{\chi_1}{n^2 kT_e}\right], \qquad (3)$$

where b_n is defined by the relation

$$\frac{N_n}{b_n} = 2{,}07.10^{-16} N_e^2 n^2 T_e^{-\frac{3}{2}} \exp\left(\frac{\chi_1}{n^2 kT_e}\right)$$

χ_1 is the ionization energy starting from the first level, N_1 and N_2 are the populations at levels 1 and 2.

3. Photoionizations and Radiative Captures. — Under the conditions of the problem

$$D_3\left(\frac{3kT_e}{2}\right) = \frac{0{,}838.10^{-1}}{N_e}\left[(0{,}42.10^{-13} N_1 + 1{,}3.10^{-6} N_2) - \sum_{n=\overline{1,2}} \frac{N_n}{b_n}\left(\frac{n^2 kT_e}{\chi_1}\exp\left(-\frac{\chi_1}{n^2 kT_e}\right) - E_1\left(-\frac{\chi_1}{n^2 kT_e}\right)\right)\right]. \qquad (4)$$

4. Inelastic and Superelastic Collisions. — To obtain a simple form of the efficient section for L_α, we had recourse to experimental results by Fite and Brackmann [4] ; in the field of energy of interest the expression $(\pi a_0^2/20)\left[(mv^2/2) - \chi_{12}\right]$ (where $mv^2/2$ is the energy of the

incident electron, χ_{12} is the excitation energy of L_α, a_o is the radius of the Bohr atom) providss a good approximation. Consequently, the contribution of these processes may be written in the form

$$D_5\left(\frac{3kT_e}{2}\right)=1{,}01.10^{-21}\,T_e^{\frac{1}{2}}\left(1+\frac{2kT_e}{\chi_{12}}\right)\left[\frac{N_2}{8}-N_1\exp\left(-\frac{\chi_{12}}{kT_e}\right)\right]. \quad (5)$$

5. Finally, to determine the populations of the levels 1 and 2 we have resolved the statistical equilibrium equations for these levels and we adopted the values $N_e\,(T_e)$ calculated by Athay, Thomas, Menzel Pecker [5] .

The equation (1) obtained by summing up the contributions given by (2), (2'), (3), (4), (5) allows the determination of the values of $T_a - T_e$ for various values of T_e.

The energy gain of electrons by ionizations and radiative captures is positive : it is essentially due to photoionizations starting from the second level. On the other hand, the contributions of excitations and ionizations by collisions are of the same order, the reverse processes being negligible. Finally, the equipartition between "heavy" particles and electrons is realized by electrons-ions' collisions, the electrons-atoms' collisions being only comparable with them at low temperatures (of the order of $6\,000^{\circ}$). The difference $T_a - T_e$ is very small (of the order of 1°), and nearly constant.

This difference varies approximately as N_a / N_e^2 ; it could thus be notably more important in a less ionized atmosphere.

REFERENCES

1. J. NAZE.- Comptes-Rendus Ac.d.Sc., 251, pp.651 and 854, 1960.

2. L. SPITZER. Physics of fully ionized gases, Interscience Publishers Inc., New York, 1956.

3. R. G. ATHAY et R. N. THOMAS, Physics of the Solar Chromosphere, Interscience Publishers, New York, London.

4. W. L. FITE & B. T. BRACKMANN, Phys.Rev. 112, 1151, 1958.

5. R. G. ATHAY, D. H. MENZEL, J. C. PECKER & R. N. THOMAS.- Ap.J., suppl., 1ere serie, p.505

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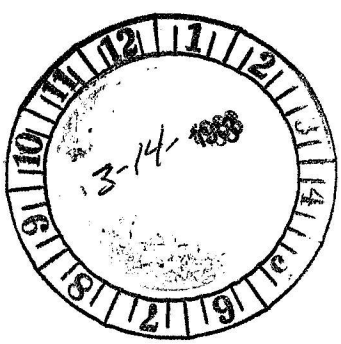
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